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RESULTS OF COTTON EXPERIMENTS IN 1911.

BY

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RESULTS OF COTTON EXPERIMENTS IN 1911.

INTRODUCTION.

Even with an annual plant like cotton most experiments have to be continued for several years before the completed results are ready to be reported. But when the work leads to the recognition of new factors that affect the crop or suggests new methods of agricultural improvement there should be no loss of time in making the results available for the information of the public or for the use of other investigators of similar problems. These purposes can be served by a brief summary of the principal conclusions that have been reached, especially those that affect general problems of breeding and crop production.

The present statement is to be considered as supplementary to that contained in the Annual Report of the Chief of the Bureau of Plant Industry for 1911. The subjects that have been treated in more detailed publications are also omitted unless further conclusions have been reached. The following subjects have received attention in recent publications of the Bureau of Plant Industry:

Suppressed and Intensified Characters in Cotton Hybrids, Bulletin 147.
A Study of Diversity in Egyptian Cotton, Bulletin 156.
Local Adjustment of Cotton Varieties, Bulletin 159.
Origin of the Hindi Cotton, Circular 42.
Mutative Reversions in Cotton, Circular 53.
Cotton Selection on the Farm by the Characters of the Stalks, Leaves, and Bolls, Circular 66.
Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana, Bulletin 198.
Hindi Cotton in Egypt, Bulletin 210.
Relation of Drought to Weevil Resistance in Cotton, Bulletin 220.
Dimorphic Leaves of Cotton and Allied Plants in Relation to Heredity, Bulletin 221.
Arrangement of Parts in the Cotton Plant, Bulletin 222.

BREEDING NEW VARIETIES OF AMERICAN UPLAND COTTON.

Several of the varieties that have been originated by this Department and sent out through the Office of Congressional Seed Distribution are gaining in popular appreciation and agricultural utility. The distribution of seed is being continued in order to permit more

thorough testing and more general adoption of the varieties as far as they prove superior to other sorts.

The Columbia cotton, an early long-staple type originated several years ago in South Carolina by Dr. H. J. Webber, proves to be well adapted to large areas in the eastern part of the cotton belt. The advance of the boll weevil has reduced the production of long-staple Upland cotton in Mississippi and Louisiana, resulting in an acute commercial demand for this type of fiber. The action of State quarantine laws against the importation of cotton from sections infested with the cotton boll weevil and the high prices realized by eastern growers of the Columbia variety have stimulated interest in this variety to the extent that all the available supplies of good seed have been exhausted for some time. Special efforts are being made to preserve the uniformity of this variety by growing new supplies of seed under conditions of isolation from other cotton and by more effective cooperation in the work of selection.

Other long-staple varieties have been developed by Mr. D. A. Saunders in Texas and Louisiana, with the object of replacing the late varieties of long-staple cotton formerly grown extensively in the Mississippi and Red River valleys. The Foster variety, of which a limited distribution was made in 1910, has given excellent results in some localities, but is too susceptible to differences in external conditions to be recommended for general planting. The variety was originated from a hybrid between two distinct types, the long-staple Upland and the Texas big-boll, which doubtless explains the tendency to variation.

Tests are also being made of two other varieties with long lint originated by Mr. Saunders by the selection of individual variations from the Texas big-boll type. One of these has much the same habits of growth as the well-known Triumph variety, but has still larger bolls and leaves of a somewhat paler green. The lint has a length of about $1\frac{1}{8}$ or $1\frac{3}{16}$ inches.

The Lone Star variety, another selection from the Texas big-boll type, is receiving wide distribution in Texas and other weevil-infested States and is giving very satisfactory results. If adequate provision can be made for maintaining the uniformity of the stock by selection the variety is likely to become as important as the now famous Triumph cotton, or perhaps even more so. The two varieties are quite similar, and under some conditions are not easily distinguishable. In other places the Lone Star shows distinct elements of superiority in the larger bolls, longer lint, and especially in the greater ability of the plants to maintain an erect position instead of becoming prostrate, as the Triumph cotton often does when it makes a luxu-

riant growth and fruits abundantly. The Lone Star also has less tendency than the Triumph to shorten the lower fruiting branches.

Another short-staple variety called Trice was bred by Prof. S. M. Bain, of the Tennessee Agricultural Experiment Station, in cooperation with the Bureau of Plant Industry. The Trice cotton is becoming popular in western Tennessee and the demand is also spreading in the adjacent regions of northern Mississippi, Arkansas, and Missouri. This variety was obtained by selection from a local stock known as Tennessee Green Seed. The Trice is an extra-early variety, more prolific than King, with larger bolls and better lint. It is much superior to the unselected stocks that are being grown in western Tennessee and is preferable to King and other eastern short-staple varieties that have been carried west as a means of securing protection against the boll weevil. But the Columbia and other long-staple varieties of cotton are also giving good results in western Tennessee, where the conditions seem to favor the production of fiber of good quality.

ACCLIMATIZATION OF TROPICAL VARIETIES OF UPLAND COTTON.

As a result of agricultural explorations made several years ago in weevil-infested regions of Mexico and Central America several new types of Upland cotton were introduced to test the possibility of their acclimatization in the United States. Some of the introduced varieties behaved in a very abnormal manner when first planted in the United States, becoming very much overgrown and unproductive and showing great diversity, but they have now returned to their normal characteristics as early and prolific members of the Upland series. Uniform strains are being bred from individual plants selected as the best representatives of their types. Four of the imported types, Kekchi, Durango, Acala, and Tuxtla, prove to have important points of superiority over any of our United States varieties of Upland cotton.

In addition to certain specialized characters that afford some protection against the boll weevil, the new sorts have very abundant lint of excellent quality and of good length, ranging from 1 to 1¼ inches. The bolls are larger than in American Upland varieties that produce as long a fiber. Two of the new types, Durango and Acala, seem to be specially adapted to conditions of dry farming and irrigation in the Southwestern States. These types have been grown in field plantings with excellent results. Still larger plantings are to be made in the coming season to test the behavior of the varieties under different conditions and to secure seed for more general distribution. The Acala type promises to become useful for general

purposes and is apparently superior to the Texas big-boll varieties now in general cultivation, while the Durango seems likely to take a prominent place among long-staple Upland varieties.

The Durango cotton has been derived from a Mexican stock, supposed to have come from the State of that name. The seeds used for the first planting were from a few bolls obtained by Mr. F. L. Lewton from an exhibit made by the Mexican Government at the St. Louis Exposition. After several years of acclimatization and selection in southern Texas a superior strain was separated, from which the present Durango variety has been developed. The Acala and Tuxtla varieties were obtained in the State of Chiapas, in southern Mexico, during an agricultural exploration of that region by Messrs. G. N. Collins and C. B. Doyle in the winter of 1906 and 1907. The existence of a big-bolled long-staple type of Upland cotton in southern Mexico had been ascertained during an expedition made by the writer in the previous summer, but seed could not be obtained at that time. The origin and peculiar characteristics of the Kekchi cotton have been described in some detail in previous publications, especially in Bulletin 88, Weevil-Resisting Adaptations of the Cotton Plant, Bureau of Plant Industry, United States Department of Agriculture, 1906.

CHARACTERISTICS OF THE DURANGO COTTON.

In cultural characters the Durango cotton is distinctly superior to the old long-staple varieties usually referred to as "Peeler" cotton, especially for irrigated districts in Texas and other Southwestern States. It is very early and prolific, flowers rapidly, and produces larger bolls than Allen, Sunflower, or other Peeler varieties. The lint is not as long as in some of the Peeler varieties, but it is much more abundant and more uniform in length—about $1\frac{1}{4}$ inches under favorable conditions. The bolls ripen early and open promptly, so that a large part of the crop can be gathered at a single picking. The plants have an open, upright habit, which gives them an advantage under boll-weevil conditions, facilitates picking, and lessens the danger of discoloration by moisture.

Another desirable characteristic of the Durango cotton is that the involucral bracts are unusually small, and hence less likely to be broken off and mixed with the fiber at the time of picking. Broken bracts furnish most of the "trash" that now figures so largely in the commercial grading of cotton. The small size of the bracts and the upright, open growth of the plants may be expected to render this variety unusually well suited to the application of cotton-picking machines, if any of these can be developed to the point of practical utility.

The most objectionable tendency observed in this variety is toward a premature ripening of the bolls, before the seeds at the ends of the locks are fully matured. Were it not for this tendency the Durango cotton could be recommended for general planting in competition with Triumph or any other short-staple sort; but other long-staple varieties show the tendency to premature opening in a greater degree than the Durango. In comparison with other long-staple types, the Durango cotton must be considered as distinctly drought resistant.

Growers of long-staple cotton are familiar with the fact that the length and strength of the fiber are likely to be diminished if the plants are checked by drought or other unfavorable conditions while the crop is being produced. The Durango cotton, being less susceptible to such unfavorable conditions, has produced good crops in localities where other types of long-staple cotton could not be grown to the same advantage. In numerous experiments in Texas and southern California the new variety has shown itself superior to all of the United States Upland long-staple varieties with which it has been compared.

The importance of the factor of local adjustment is well shown by differences in the behavior of the Columbia cotton when grown in comparison with the Durango. In South Carolina, where the Columbia cotton was bred, it is an excellent variety, with a long, strong, and uniform staple. But when grown in Texas and southern California the Columbia cotton is markedly inferior. Many plants produce only short, weak lint that would not be considered as premium cotton, and there are other departures from the normal characters of the variety in the habits of growth, leaves, and bracts. Continued selection of the more normal plants under the western conditions would doubtless improve the behavior of the variety, but in view of the superior adaptation of the new Durango type it seems hardly worth while to attempt to adjust the Columbia cotton to the western conditions.

LONG-STAPLE COTTON AS AN IRRIGATED CROP.

The possibilities of producing long-staple cotton are worthy of a careful consideration in all of the irrigated districts of the Southwest. The popular idea has been that the production of a long, strong fiber was necessarily limited to regions with a humid atmosphere, like the Sea Islands of South Carolina or the Delta region of the Mississippi Valley. In reality, however, the production of fiber of high quality does not depend upon atmospheric conditions, at least to any such extent as has been supposed.

As long as the soil affords an adequate and readily available supply of moisture, a high degree of atmospheric humidity is not necessary. A dry atmosphere is injurious, of course, if it renders the supply of

moisture in the soil inadequate and thus reduces the plants to a condition of drought. But with soil of the right texture and a supply of moisture that can be replenished by irrigation it is possible to maintain equable conditions and produce cotton of very high quality. This has been conclusively shown in experiments with Egyptian cotton in Arizona and southern California, and with the Durango cotton in southern Texas.

The general tendency in irrigated districts is to use too much water, the ability of the cotton plant to resist drought being underestimated. The crop is easily injured by the excessive use of water, especially in the earlier part of the growing season. In localities where the natural rainfall assisted by dry-farming methods provides enough moisture for the germination of the seed, it is better to use irrigation only to protect the maturing crop against injury by too severe drought.

To raise short-staple Upland cotton on irrigated lands where Egyptian or long-staple Upland cotton can be grown must be considered as a waste of agricultural resources. It is true that short-staple cotton can be produced and marketed with less difficulty and by more careless methods. This may justify the planting of short-staple cotton by inexperienced farmers or in new settlements, but as soon as communities become better organized an increased production of long-staple cotton is to be expected from the irrigated regions of the Southwest.

Though many irrigation enterprises have been undertaken in the hope of producing high-priced truck and fruit crops, cotton seems likely to become the chief product of irrigated lands in Texas, as well as of those that are cultivated by dry-farming methods. Promoters of irrigation enterprises often fail to appreciate or to call attention to this prospect, perhaps for the reason that short-staple cotton would not appear as a profitable crop for lands enhanced in value by the cost of irrigation works and water rents. Indeed, it is still very difficult to understand how any crops now in sight will justify the high prices that are expected for some of the irrigated lands. In regions where alfalfa does not thrive, as in some parts of Texas, cotton is all the more likely to become the chief dependence of irrigation farming.

EXTENSION OF COTTON CULTURE IN THE SOUTHWEST.

A gradual extension of cotton culture into the drier region of Texas and other Southwestern States is one of the agricultural movements now in progress. The boll weevil can do less damage in a dry climate. The injured buds fall off and dry up more promptly and this destroys the weevil larvæ. Cotton resists drought better than most other crops and seems likely to be the chief product of large tracts of

country in southern and western Texas that are now being occupied by farming communities. This movement is going forward rapidly, and hundreds of settlements are being opened. Many of the more extensive cattle ranges of former years are being plowed and planted, not merely because the land has become valuable for agricultural purposes, but because the rapid extension of mesquite and other woody vegetation has restricted the supply of grass and greatly reduced the value of the land for grazing purposes.[1]

There is no apparent reason why this extension of the cotton belt to the westward should not make good the losses caused by the boll weevil in the more humid regions of the East. On the other hand, the greater diversification of farming in the regions where cotton is becoming a more precarious crop tends to compensate for the restriction of range facilities in the West. The former cattle country is producing cotton and the cotton country is showing renewed activity in the production of cattle. The boll-weevil invasion has stimulated activity in the extermination of the cattle tick.

The higher cost of labor and transportation in the Southwest is largely compensated by protection from weevils and favorable weather in the long picking season. There is seldom any rain to damage the cotton by beating it down to the ground or to discolor or rot the fiber in the bolls, as often happens during periods of wet weather in the more humid Eastern States. This is particularly important, of course, in connection with the production of the high-grade long-staple cottons that are likely to be grown in irrigated districts.[2]

COTTON IMPROVEMENT ON A COMMUNITY BASIS.

A general study of this subject shows that many factors of improvement could be much more effectively utilized if cotton-growing communities were organized to grow a single variety of cotton and maintain its uniformity by selection. The present multiplicity and

[1] Change of Vegetation on the South Texas Prairies. Circular 14, Bureau of Plant Industry, U. S. Dept., of Agriculture, 1908.

[2] One well-known investigator of the weevil problem has gone so far as to suggest an ultimate transfer of the entire cotton industry of the country into the dry Southwestern States:

"The time will no doubt come when cotton production will be abandoned in the humid area of the Southern States, and the area of production of this crop transferred to the warm arid region just mentioned. When the boll weevil has become distributed throughout the present cotton area of the United States, the annual loss from its effects, in spite of all methods and agencies that can be brought to bear against it, will probably exceed $50,000,000. Why should this loss continue to be incurred and carried year after year, when a new cotton region which will produce a far higher grade of fiber worth a higher price awaits exploitation?

"Let the Southern States raise other crops that are better suited to their conditions, and move the area of cotton production to the Southwest, where it belongs. The boll weevil will not trouble it there. Such action will not be realized for several decades, it is safe to say, and I will no doubt be set down as a foolish theorist for making the suggestion. However this may be, I rely upon my firm conviction that the change will come eventually and that time will prove the soundness of the suggestion." See Townsend, C. H. T., "The Cotton Square-Weevil of Peru and Its Bearing on the Boll-Weevil Problem in North America," Journal of Economic Entomology, vol. 4, 1911, p. 248.

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mixing of varieties is a serious obstacle to the improvement of the industry.

In a community that planted only one kind of cotton the crossing of varieties in adjacent fields and the mixing of seed in gins would be avoided, selection could be made more effective, and the production of a larger quantity of uniform fiber would enable growers to obtain higher prices. The danger of weevil injury would be diminished if communities could also agree upon dates of planting and make a combined effort to have the fields cleared of stalks early in the fall. Special attention should be given to establishing improved varieties and methods of selection in communities organized for the production of a single type of cotton.[1]

METHODS OF DISTRIBUTING SUPERIOR VARIETIES.

A study has been made of the results of sending out seed of improved varieties of cotton through the Office of Congressional Seed Distribution to see whether the usefulness of the system could be increased. The custom has been to send the seed out in 1-peck packages, with the idea of enabling the farmer to plant the new variety on a field basis by the second or third year. But there are several reasons why much of the seed is wasted, or at least fails to serve the intended purpose.

Many of the packages are not used for planting, being sent to people who are not growing cotton. Some of them go to farmers who do not "bother" with such a small quantity of seed. Many farmers plant the improved seed by the side of other cotton, or even mix it with their local variety before planting, with an idea that the whole stock can be improved in this way. Very few farmers observe the precautions necessary to avoid crossing with other varieties in the field or mixing the seed at the gin. To avoid admixture of seed the gin has to be thoroughly cleaned out. This means extra time and trouble that many farmers are unwilling to take. The purity of the new stock is usually destroyed in the first season.

After the cotton is grown other difficulties appear in the separate picking, ginning, and marketing of a single bale or a part of a bale of a different kind of fiber, especially if the new variety is one that produces a longer staple than the local sorts. Mixed bales, containing two kinds of cotton, are refused by buyers. These difficulties are often avoided by selling the small stock of improved cotton in the seed, so that the variety is lost to the farmer. Only a small part of the seed that is sent out through the general distribution is really made use of for introducing the new variety into cultivation.

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[1] A more extensive statement of the advantages to be secured by the organization of cotton-growing communities may be found in the Yearbook of the Department of Agriculture for 1911, pp. 453–466.

Thus it is seen that the packages sent out in the past have been too large for some purposes and too small for others. The crop raised from a peck of seed can hardly be discarded as a mere casual experiment, but is usually too small to receive separate treatment in ginning and marketing. Unless the first planting of a new variety is isolated from other cotton, the seed should be discarded and another beginning made, preferably with seed enough to plant at least a small isolated field and produce at least one full bale of the improved fiber.

It has become evident that two or three distributions of a few superior varieties are likely to be of much more use than single distributions of a larger number of varieties. The chief object of such distributions is not to increase the number of varieties, which is already too large, but to secure the widest utilization of the best varieties. To accomplish this purpose it is necessary not only to breed new varieties, but to maintain the select stocks for a period of years, at least long enough for the public to become acquainted with the variety and for local breeders and seedsmen to develop supplies of good seed.

The problem of distribution is obviously to get more of the select seed into the hands of men who are sufficiently interested to make use of it as a means of establishing the culture of the new variety in their local community. To avoid the present waste of seed in the general distribution it has been recommended that the packages of seed used for this purpose be reduced to 1 quart. This smaller amount will serve the general purpose of affording the farmer an opportunity to become acquainted with the new variety and to decide whether he cares to adopt it.

The seed saved by reducing the size of the packages in the general distribution is to be used for a special distribution of larger amounts of seed to a limited number of farmers who report the best results from the first small package and who are ready to give special attention to the new variety in order to keep the seed pure and market the improved crop separately. In the distribution of the larger packages preference should be given to districts or communities that are favorably situated and well organized, so that they can devote themselves to the production of a single superior variety. In addition to the reports that are furnished regarding the results of the first planting, farmers are to be asked to send small samples of the cotton they have raised. This method will secure more definite information regarding the behavior of varieties in different parts of the cotton belt and make it possible to place the special distributions to the best advantage. Well-organized communities are also to be encouraged as far as possible by expert advice and assistance in growing, selecting, and marketing the improved varieties.

PRESERVATION OF SUPERIOR VARIETIES BY SELECTION.

One of the chief factors in the improvement of all agricultural industries, the utilization of better varieties, is largely nullified by the failure of the cotton-growing public to understand and observe the precautions that are needed to preserve the uniformity of improved stocks. The breeding of a superior variety of cotton represents an improvement of the industry only to the extent that the stock is preserved and continued in cultivation. With selection neglected, the uniformity of a strain is soon lost, usually before its agricultural value can be realized and even before it is brought into general cultivation. Selection is quite as necessary for the preservation of old varieties as for the development of new ones. Such selection is quite distinct, both in object and method, from that employed by a breeder in developing a new variety or in finding superior individuals and comparing their progenies. The modern school of biologists may be right in supposing that little or nothing can be obtained in the way of further improvement after a definite varietal type has been separated. But this has nothing to do with the fact that continued selection is a necessity to keep any select stock from losing its uniformity by crossing with degenerate mutations that continue to appear, even in pure strains, from self-pollinated plants.[1]

Though it is of the highest importance with cotton to use select seed in order to secure good yields and uniform fiber, the present system of seed production is altogether inadequate and entails annual losses of enormous proportions. To say that the average yield could be increased 10 per cent and the quality improved to a similar extent by the use of better seed are conservative estimates amply justified by many experiments in different parts of the cotton belt. Yet if these factors of improvement could be applied to the whole cotton industry of the United States their annual value would reach a very large figure.

Owing to the relatively small number of seeds produced by the individual plant and the relatively large number that have to be planted, there is no prospect that the production of high-grade seed can be centralized in the hands of commercial seed growers or dealers, as with other crops. The great bulk of the crop will continue in the future, as in the past, to be grown from seed raised on the same farm or at least in the same community. Moreover, all the experiments indicate that properly selected home-grown seed is likely to give better results than any newly imported stock, even of a superior variety. The production of local supplies of high-grade seed is one of the fundamental objects of community organization.

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[1] Bain, S. M. A Cotton Variation with a Self-Fertilized Ancestry. American Breeders' Magazine, vol. 2, No. 4, 1911, p. 272.

IMPORTANCE OF BREEDING VARIETIES WITH DISTINCTIVE CHARACTERS.

Since the value of a superior variety depends very largely upon the preservation of uniformity after it has been introduced into cultivation, means of maintaining uniformity must be taken into account in breeding. Varieties with distinctive peculiarities, especially in the vegetative parts of the plants, are more valuable because it is easier to detect and remove undesirable individual variations that would otherwise destroy the uniformity of the stock. Preference is being given to the breeding of new varieties that have readily distinguishable characteristics, and the distinctive characters of existing varieties are being determined in order to give a better basis for selection.

The big-boll long-staple selection bred by Mr. Saunders in Texas, as already stated, has foliage of a slightly paler green than other varieties of Upland cotton. Plants with darker foliage are always found to depart from the type in other respects, having smaller bolls and shorter and less abundant lint. The difference in color makes it easier to recognize and remove from fields or breeding plats such variations of this pale-leaved strain.

Seedlings of numerous varieties of Egyptian and Upland cotton have been compared with a view to the development of methods for detecting undesirable variations in the early stages of growth. It has been found that the Hindi variations of Egyptian cotton can be recognized immediately after germination by differences of the cotyledons or seed leaves. Those of the Hindi cotton are larger and smoother, are marked with red along the veins, and have a reddish callus at the base.

Differences in the forms of the first series of true leaves also permit some of the varieties to be distinguished in the early stages of growth. Egyptian varieties usually have five or six simple leaves at the base of the stalk before the lobed leaves begin to appear. Upland varieties have fewer simple leaves and some show lobed leaves from the first. The involucral bracts that inclose the flower buds afford another series of characters of use in distinguishing varieties.

JUVENILE LEAF-CURL OF COTTON.

Malformation of the leaves is a widespread disorder of young cotton seedlings. Many of the seedlings with malformed leaves also lose the terminal bud. This disorder forces the development of vegetative branches from the axils of the cotyledons and from other joints at the base of the stalk. Though such plants always recover, in the sense that they afterwards produce normal leaves, flowers, and bolls, they are more or less misshapen, mature later than uninjured plants, and produce a smaller crop. Retarded and irregular growth is particu-

larly undesirable in weevil-infested regions, where a prompt development of the crop is of the utmost importance in avoiding weevil injury.

Though generally confused with a distortion of the leaves caused by plant lice, the juvenile leaf-curl is quite independent of the presence of these insects. Both kinds of malformation are often to be found on the same plant, but they are not of the same character. The juvenile leaf-curl may be distinguished by the fact that it is usually accompanied by irregular holes or incisions in the leaves that do not occur when plant lice alone are involved. Nothing has been found to indicate that the juvenile leaf-curl is due either to insects or to parasitic fungi or bacteria. All the damage is done, apparently, while the leaves are still in very early stages of development. The parts that remain uninjured appear to be entirely normal.

The underlying cause of the juvenile leaf-curl is still obscure, but it is evident that the malformations result from the death of some of the cells of the leaves during the early stages of growth. If only a few cells die, the result is a simple puncture of the leaf surface. The loss of larger groups of cells results in more serious malformations and even in the abortion of the whole terminal bud. Thus the distorted leaves and the aborted terminal buds may be considered as merely different symptoms of the same form of injury to cells of the seedlings. The petioles of the leaves show another injury in the form of long narrow gashes, as though cut lengthwise with a knife. It is to be expected that corresponding malformations will be found in young plants of other species. Mr. G. N. Collins has called the writer's attention to a peculiar lobing of the leaves of Indian corn, which may be of the same nature.

That the injuries begin at very early stages in the development of the leaves is shown by the fact that wounds are often healed, or some of the lost parts may be regenerated from adjacent tissues. As a result of healing the wounds, the leaves often have a peculiar broken-and-mended appearance. A similar condition is sometimes found in the leaves of abnormal hybrids and mutations, but in these cases the abnormality continues through the whole life of the plants. This analogy might be taken as a confirmation of the idea that the cause of the malformation is to be found in the injury or death of some of the cells at very early stages of the development in the bud, while it is still possible for new cells to be formed by proliferation.

The popular belief that the leaf-curl is much more severe during periods of cold weather may mean that some of the cells are killed by cold. Or it may be that cold has the effect of delaying division or other cytological processes that normally occur at night. Such a delay would render the cells more susceptible to injury from sudden exposure to heat or sunlight in the morning. It has been noticed

that plants less exposed to the sun show less of the leaf-curl, while those that are well shaded or grow in diffuse light, as in a greenhouse, are not affected. If too much exposure of the young plants to the sun is the cause of the injury it may be possible to secure protection by later planting or more gradual thinning. It is to be considered that the growing tissues of the young seedlings are probably exposed to greater extremes of heat and dryness than those of more mature plants, because they are closer to the heated surface of the soil. After a cold night the young plants often appear badly wilted in the morning, an hour or two after sunrise, perhaps because the leaves are heated before the roots are warm enough to absorb water rapidly. Injuries due to sudden exposure in the morning are often ascribed to frost. Cotton seedlings may be killed in this way although the night temperatures remain above the frost line. This fact was shown some years ago in experiments with cotton in Guatemala.

METHODS OF UTILIZING FIRST-GENERATION HYBRIDS.

It has long been known that hybrids between Upland and Egyptian cotton produce lint of superior quality. The hybrids are also more vigorous and productive than pure-bred varieties, and better able to withstand unfavorable conditions. Many attempts have been made to breed superior hybrid varieties, but the later generations always prove inferior to the first, or to the parent varieties. Many of the plants have short or sparse lint or are weak and infertile.

Accepting the fact that the superiority of the hybrids is limited to the first generation, other possibilities of utilization are being investigated in southern California. Experiments have been made by Mr. Argyle McLachlan with two methods of producing hybrid seed, hand pollination and natural crossing by bees. The former process would be rather expensive, but the methods have been so simplified that the cost would not be prohibitive.

The production of hybrid seed through natural crossing by insects is facilitated by planting the parent varieties in alternate rows. As only a part of the seed will produce hybrid plants, the feasibility of this method depends on the possibility of recognizing the hybrids in the early stages of development and pulling out the remainder of the plants. Studies of the characters of young seedlings have shown that the hybrids can be distinguished in the early stages of growth. The proportion of hybrids in any particular lot of seed would depend, of course, on the number and activity of the bees or other cross-fertilizing insects at the time of flowering, and this varies greatly in different localities and in different parts of the season.

The utility of the hybrids would be increased if two or more crops of cotton could be obtained from the same plants. The winters of southern California are not cold enough to kill the roots, and the

Egyptian cotton has the habit of forming subterranean shoots when the stalks are frozen to the surface of the ground below the level of the original seed leaves. The new shoots appear in the form of irregular nodules, with a superficial resemblance to crown galls. They probably represent the development of dormant root primordia, for they always arise from the four grooves where the lateral roots come out from the taproot, never from other parts of the surface. The first leaves of these regenerated shoots are very irregular in shape, but the normal form is soon attained and the new stalk makes an entirely normal development.[1]

The readiness of the Egyptian cotton in forming these subterranean buds on the overwintered roots suggested the idea that cuttings would callous and root readily under the same conditions and thus open up a third possibility of utilizing hybrids by propagation from cuttings. The first attempt of this kind was made by Mr. McLachlan in May, 1911, with cuttings of new-wood branches that had developed on overwintered plants. Notwithstanding the lateness of the season and the absence of any special care or precaution to induce the rooting of the cuttings, about 10 per cent survived and grew into very vigorous and productive plants. The possibility of carrying such cuttings through the winter by different methods of protection and handling is being tested at Bard, Cal.

CONTROLLING THE FORMATION OF BRANCHES IN EGYPTIAN COTTON.

Previous experiments having demonstrated the possibility of producing Egyptian cotton of high quality in the irrigated districts of Arizona and southern California, it becomes necessary to understand the cultural peculiarities of this type of cotton. The most obvious cultural difference between the Egyptian and Upland types of cotton is the greater vegetative vigor or luxuriance of the Egyptian. Though the Upland cotton is similarly affected by combinations of fertile soil, moisture, and heat, the Egyptian cotton is much more susceptible and often grows two or three times as tall as Upland cotton planted in adjacent rows.

In addition to the greater height of the plants, the Egyptian cotton also produces a much larger number of large "wood limbs" or vegetative branches. Under field conditions these branches grow in an upright or ascending position, forming so dense a mass of foliage that no normal fruiting branches can develop on the lower part of the plant. The result is that fruiting is largely confined to the top of the plant, making the crop very late in comparison with Upland cotton.

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[1] Arrangement of Parts in the Cotton Plant. Bulletin 222, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, p. 23.

The large size of the plants increases the labor of picking, and much of the crop is lost by the breaking down of the branches between the rows. These are the most serious difficulties in the development of an Egyptian cotton industry in the irrigated districts of Arizona and southern California.

When the Egyptian cotton is grown under conditions that do not induce luxuriant growth the behavior is much like that of Upland cotton. The plants are low and spreading, with open foliage, and the bolls develop about as rapidly as those of Upland cotton. This Uplandlike behavior has been observed when the Egyptian cotton was grown in cool climates, as in the vicinity of Washington, D. C., and near Los Angeles, Cal. This is also the normal behavior of the plant in the lower part of the Nile Valley, where most of the Egyptian cotton is raised. The temperatures are kept low by the north winds that regularly blow in from the Mediterranean.

Early planting has been advised in California as a means of restricting the development of the vegetative branches, because fewer branches are produced during the cooler weather of early spring. But the advantage that may be gained in this way is easily lost, for a sudden access of warm weather is likely to throw the plants into luxuriant growth and induce the development of vegetative branches from all of the lower joints of the stalk.

Apart from the influence of cold weather in keeping the plants from becoming too luxuriant, experiments have shown that there are two other factors, moisture and exposure to sunlight, that govern the development of vegetative branches. Plants that grow from the outset in dry soil, even though standing alone and fully exposed to high temperatures and to full sunlight, often fail to develop any vegetative branches, but begin to produce fruiting branches only a few inches from the ground. When cotton is grown under irrigation it is possible to restrict the production of vegetative branches by withholding water in the early part of the season until the fruiting stage is reached.

The development of vegetative branches is also restricted when the plants stand close together so as to shade the lower joints of the main stalk, which produce most of the vegetative branches. If the plants are thinned too early, so that the lower joints are exposed before there is enough foliage to keep them shaded, vegetative branches are likely to be put forth at each joint and even from the axils of the cotyledons or seed leaves. But if the plants are allowed to stand closer together or are thinned gradually they may not produce any vegetative branches.

There are obvious limitations, of course, in the use of dryness and shading to prevent the development of vegetative branches. If the

plants are kept too dry they make only a slow growth. If allowed to stand too close together they remain weak and spindling. The practical problem is to use the two factors in proper combination, so as to suppress the vegetative branches without interfering with the growth of the main stalk and the fruiting branches. Further experiments are to be made in this direction.

If the plants can be kept from developing any vegetative branches it will be possible to let them stand only 12 or 15 inches apart in the rows instead of 3 or 4 feet apart, as has been considered necessary, and the rows will not need to be more than 3 or 4 feet apart instead of 5 or 6 feet. This control of the branching may enable the yield to be increased, and at the same time cultivation and picking will be greatly facilitated.

A control of the branching would also enable the crop season to be shortened, since one of the chief reasons for early planting would be removed. It would become much more feasible to alternate Egyptian cotton with winter crops. Cold weather, juvenile leaf-curl, and plant lice usually conspire to make the growth of the plants very slow during the spring months. There is nothing to show that later planting would lessen the crop or even delay maturity if there were other ways of controlling the formation of the branches.

EGYPTIAN COTTON LESS SUSCEPTIBLE TO SHEDDING.

In another cultural character the Egyptian cotton compares more favorably with the Upland type. This character is the greater freedom from shedding or abortion of the buds and young bolls. Perhaps on account of its deeper root system the Egyptian cotton is often able to retain its buds and young bolls under conditions that cause extensive shedding in adjacent rows of Upland cotton. Shedding occurs in the Egyptian cotton when the vegetative branches grow up and shade the lower fruiting branches, but there is no such general shedding of buds and young bolls as usually results from a sudden checking or forcing of growth in Upland cotton.

Losses from shedding are often quite serious in irrigated regions, each application of water causing many buds to fall. The effect is much the same as when the boll weevil is present. The plants grow large and luxuriant, but have only a few bolls. This was noticed especially in an experimental field of Columbia cotton raised at El Centro, in the Imperial Valley of California, in 1911. An adjacent planting of Durango cotton, though it had suffered in the same way, produced a much larger crop. While it may be possible to avoid such losses by working out better methods of culture and irrigation, the general fact that the Egyptian type of cotton is less susceptible to shedding than the Upland type is an important consideration.

EGYPTIAN COTTON AS A FAMILY CROP.

The Egyptian cotton is also superior to the Upland type from the standpoint of what may be called domestic or household production; that is, by the work of the settler and his own family. It is much lighter work to pick Egyptian cotton than to pick a short-staple crop of equal value. This is because the actual weight is less with the Egyptian cotton and because more careful methods of picking must be used. The Egyptian plants are taller and more erect, so that the picker stands in an upright position. This makes the work easier and lessens the exposure to the sun. There is also more shade in the Egyptian fields, on account of the larger size of the plants. With the small or prostrate Upland plants most of the work must be done with the body in a stooping position or while kneeling on the ground, with the back exposed to the sun. At the same time the movements of the body are impeded by a large picking sack, which pickers of Upland have to drag through the field. Large sacks will not be used with the Egyptian cotton because they admit too much "trash" or broken leaves.

It takes longer to pick the Egyptian cotton because of the smaller size of the bolls and the need of greater care to keep the fiber clean. The greater care takes more time, of course, but lightens the physical exertion. Indeed, it would be difficult to mention any other form of outdoor work in which women and children can assist to better advantage.

Another feature that adapts Egyptian cotton to household production is that it is easier to pick the cotton clean in the morning and afternoon when the bracts and dead leaves are not so brittle as in the middle of the day. With hired labor it is scarcely feasible to interrupt picking for several hours in the middle of the day, but this is an advantage if the housewife and children are to do a share of the work. The prejudice against outdoor work for women and children is giving way before a realization of the superior healthfulness of activity in the open air. Children make better educational progress when they are allowed a share in the activities of their parents. Town children spend most of their waking hours with other school children of their own age and have only slight contacts with parents or with practical affairs of life. For children to help their parents with such farm operations as picking cotton is also entirely different from having them work in gangs or in factories.

Unlike perishable fruits and truck crops, the cotton does not spoil if picking has to be interrupted for a day or even for a week, nor does it have to be packed and shipped as soon as gathered. Many families could pick two or three bales of Egyptian cotton without serious difficulty, for the harvest season is very long, three months or more. Even a single bale of Egyptian cotton, worth about $100, would be a welcome addition to the income of many a pioneer family. The

money return, at present prices, would be as great as for twice as much short-staple cotton and with a much smaller amount of heavy labor.

If each settler were to plant 2, 3, or 5 acres of Egyptian cotton to supplement the poultry yard, the kitchen garden, or the small fruit orchard, a considerable production would be possible, quite independent of the possibilities of utilizing hired labor by farmers who operate on a more extensive scale. But this resource is necessarily limited to communities that grow enough cotton to provide facilities for ginning and marketing.

EGYPTIAN COTTON NOT ADVISED FOR TEXAS.

As yet there is no reason to believe that the success obtained with Egyptian cotton in Arizona and southern California can be duplicated in Texas. There have been numerous experiments with Egyptian cotton in Texas and some have appeared quite successful, but the results as a whole do not warrant the idea that Egyptian cotton is a promising crop for Texas.

There are two principal differences between Texas and the more western States—the presence of the boll weevil and the hotter weather of the spring season. The warmer weather of the spring months in southern Texas is detrimental to the Egyptian cotton because it brings the plants into a condition of luxuriant growth at a stage too early in their development. The result is to induce the production of a large number of vegetative branches. The plants soon require more moisture than is usually available under the Texas conditions and are seldom able to set a crop. With hot weather and plenty of moisture the Egyptian cotton grows to enormous size and matures very late, and this increases the danger of injury by the boll weevil.

There is an untried possibility that the breeding of earlier varieties of Egyptian cotton or the discovery of improved cultural methods for controlling the growth of the plants may make it feasible to grow Egyptian cotton in some of the irrigated districts of southern Texas. Egyptian fiber of excellent quality was produced under irrigation at San Antonio in 1911, the season being so dry that the weevils did very little damage. But if a commercial culture were to be maintained it would be necessary to confine the Egyptian cotton to isolated communities where no Upland cotton would be planted. Isolation would be necessary to prevent the contamination of the Egyptian cotton by cross-pollination with the Upland and also to avoid the boll weevils that breed on the Upland cotton earlier in the season.

CONCLUSIONS.

Improved varieties of American Upland cotton bred by the Department of Agriculture and sent out through the Congressional Seed Distribution are being utilized for the improvement of the cotton industry.

New types of Upland cotton, introduced from weevil-infested regions of Mexico and Central America, have been acclimatized in the United States and have given excellent results in Texas and other Southwestern States.

One of the new varieties from Mexico, called Durango, is the most promising Upland long-staple cotton for irrigated districts. Long-staple cotton is likely to become one of the most important crops in the irrigated regions of Texas and other Southwestern States.

Cotton-growing communities have much to gain by cooperative organization for the production and marketing of a single superior variety of cotton.

An improved method of distributing select varieties has been devised to avoid waste and encourage the production of superior fiber on a community basis.

The necessity of continued selection to preserve superior varieties has been demonstrated and improved methods of selection have been devised. The value of distinctive characters that enable the plants to be recognized in the field is being taken into account in the breeding of varieties.

Cultural methods are suggested for avoiding malformations of young seedlings, which often delay the development of the plants and reduce the yield.

Several methods of utilizing superior first-generation hybrids between Egyptian and Upland varieties of cotton are being tested, including the propagation of such hybrids from cuttings.

Experiments have shown the possibility of controlling the development of vegetative branches by thinning the plants gradually and restricting the supply of water in the early stages of growth.

The Egyptian type of cotton proves to be less susceptible to the shedding of the buds and young bolls than the Upland cotton, which is an additional element of security for the crop.

Differences in habits of growth and methods of picking render the Egyptian cotton superior to the Upland type as a family crop.

The successful production of Egyptian cotton in Arizona and southern California does not justify expectations of similar results in Texas, where the conditions are essentially different. The Durango variety is preferable for irrigated districts in Texas.

Approved:

JAMES WILSON,
Secretary of Agriculture.

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